Before the
Federal Communications Commission
Washington, D.C.20554

In the Matter of	)	
	)	
Implementing Public Safety Broadband Provisions of the Middle Class Tax Relief and Job Creation Act of 2012	)	PS Docket No. 12-94
	)	
Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band	)	PS Docket No. 06-229
	)	
Service Rules for the 698-746, 747-762 and 777-792 MHz Bands	)	WT Docket No. 06-150

COMMENTS OF ACCESS SPECTRUM, LLC

The First Responder Network Authority (FirstNet) has been charged with the critical responsibility for establishing a nationwide public safety broadband network (PSBN) in the 700 MHz band. To help FirstNet carry out this important duty, the Commission has proposed unified technical service rules to govern the PSBN, with a goal of mitigating the potential for harmful interference to PSBN users as well as users in other bands.[1] Access Spectrum supports this goal and, consistent with it, urges the FCC to ensure that the new service rules avoid harmful interference to operations in the Upper 700 MHz A Block, a 2x1 MHz block that is immediately adjacent to the Upper 700 MHz D Block.

Avoiding such interference will not require burdensome requirements to be imposed on the PSBN. To the contrary, because cellular Long Term Evolution (LTE) operations in the

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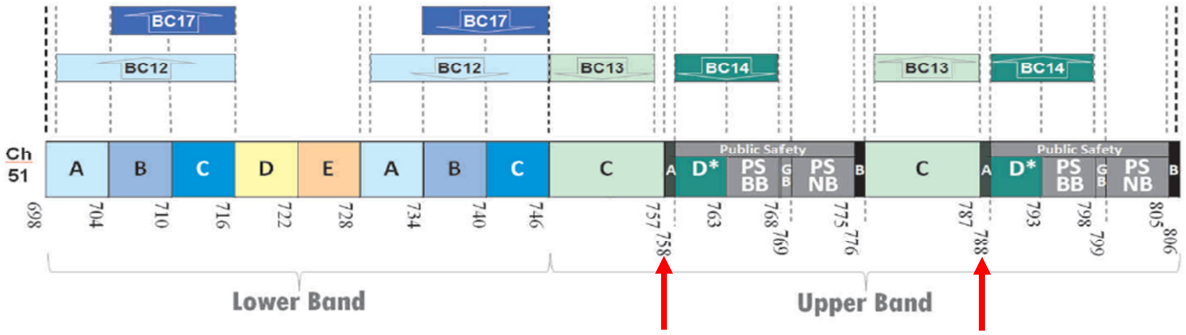
[1] *See*, *e.g.*, *Implementing Public Safety Broadband Provisions of the Middle Class Tax Relief and Job Creation Act of 2012*, Notice of Proposed Rulemaking, 28 FCC Rcd 2715, ¶¶ 1, 17, 19 (2013) (NPRM).

PSBN are expected to be compatible with similar systems in neighboring bands,[2] it appears likely that in many cases the Commission can achieve adequate interference protection simply by applying the rules proposed in the NPRM (many of which currently govern public safety broadband spectrum) to the D Block. With appropriate interference protections in place, Access Spectrum and other stakeholders will be able to continue to explore various options for developing valuable A Block spectrum.

I. Background

As the following diagram illustrates, the A Block is a 2x1 MHz block of spectrum situated between the Upper 700 MHz C and D Blocks.



Access Spectrum is one of three companies that hold licenses for the A Block throughout the United States.[3] The adjacent C Block is licensed to Verizon Wireless for next-generation mobile voice and broadband data services, while the D Block has been assigned to FirstNet to operate the PSBN.

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[2] PSBN technical standards are required by statute to be based on commercial LTE standards. Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, 126 Stat. 156, § 6203(c) (2012) (Spectrum Act). In addition, it is anticipated that FirstNet's public safety system will leverage cellular system architectures. See F. Craig Farrill, Proposal to FirstNet Board, at 7, 10 (Sept. 25, 2012) (touting benefits of leveraging infrastructure of mobile network operators, including "over 285,000 cell sites in place"), *available at* http://www.ntia.doc.gov/files/ntia/publications/firstnet_fnn_presentation_09-25-2012_final.pdf.

[3] The other two A Block licensees are BPC Spectrum LLC and Dominion 700 Inc.

All three of these blocks have superior propagation characteristics that enable broader wireless coverage at lower cost than in other bands, and the FCC's rules permit all three to be used for a broad range of applications, including cellular operations for mobile voice and data services. Access Spectrum has leased A Block spectrum to support "smart grid" communications in certain markets, and is actively exploring other services and applications for this valuable spectrum. One particularly attractive option would involve adding the A Block to FirstNet's public safety spectrum, as explained in section III below. In addition, A Block licensees are considering various new commercial uses of their spectrum.

For example, Access Spectrum recently commissioned laboratory and field trials that demonstrated that Time Domain Duplex (TDD) technology can be deployed in the A Block in full compliance with FCC rules and without interfering with adjacent spectrum. Further, the trials demonstrated the ability to transmit voice, data, and video in a secure manner, at speeds up to 850 kbps using off-the-shelf equipment in a 700 kHz TDD channel (a significantly higher throughput would be possible with customized equipment). The tests also demonstrated the feasibility of a number of specific applications, including basic IP traffic using peer-to-peer networks, financial transaction processing, broadcast/beacon (control channel) uses, and telematics. Access Spectrum is pursuing opportunities to commercialize these applications, and believes their deployment in the A Block would benefit the public by allowing cutting-edge services to be provided on a nationwide basis without propagation problems (such as poor indoor reception) that would occur in higher frequency bands.

II. The New Service Rules Should Protect Systems Operating in the A Block from Harmful Interference

In the NPRM, the Commission seeks to adopt technical rules governing the D Block and the existing public safety broadband spectrum "to protect against harmful radio frequency

interference" to public safety systems as well as systems operating in adjacent bands, including the A Block.[4] Many of the proposed rules would appear to provide adequate interference protection to A Block systems. For example, section 27.53(d)(3) currently requires D Block spectrum emissions into adjacent commercial spectrum to be attenuated by at least 43 + 10log (P). Applying this limit to the entire public safety broadband spectrum, as discussed in the NPRM, would help avoid harmful interference to users of the A Block and, as a result, would help preserve the flexibility of stakeholders to explore various options to develop the A Block.[5]

The Commission should not lose sight of this goal as this proceeding moves forward. Although the Commission initially established the A Block as part of a "guard band" to protect public safety narrowband operations, the A Block no longer serves this purpose. In 2007, the Commission relocated the A Block to its current location between the Upper 700 MHz C and D Blocks. Because the A Block is no longer adjacent to public safety narrowband spectrum and no longer serves as a guard band, the Commission's 2007 order also eliminated a number of restrictions on A Block licensees to maximize their flexibility in developing this valuable block of spectrum.[6] As described in section I above, Access Spectrum is actively exploring various

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4 NPRM ¶¶ 14, 17, 22.

5 *See* NPRM ¶ 25.

6 Originally, FCC rules imposed restrictions on A Block operations, including a prohibition on the use of cellular system architectures, because at the time the A Block was directly adjacent to the public safety 700 MHz narrowband block. As described above, however, in 2007 the Commission relocated the A Block to its current location between the Upper 700 MHz C and D Blocks. Access Spectrum accepted this license modification – including the relinquishment of valuable spectrum – on the understanding that the FCC would eliminate the cellular prohibition and other restrictions that might restrict the flexibility of stakeholders to develop the A Block. *See* Letter from Access Spectrum, *et al.* to Marlene H. Dortch, FCC Secretary, WT Docket Nos. 96-86, 06-150 and 06-169; PS Docket No. 06-229 (July 26, 2007). Consistent with this understanding and because the A Block is no longer adjacent to public safety narrowband operations, the Commission in 2007 eliminated the cellular prohibition as well as frequency coordination requirements that previously applied to A Block licensees, and applied to the A Block the same OOBE limits that apply to the Upper 700 MHz C Block. *See Service Rules for*

options to take advantage of this flexibility, including deploying innovative new commercial systems and applications in the A Block. The Commission therefore should ensure that the final PSBN service rules safeguard A Block operations against harmful interference and thus permit the flexible development of the A Block consistent with the Commission's 2007 order.

III. Incorporating the Upper 700 MHz A Block in the PSBN Would Advance FirstNet's Statutory Mission by Enhancing Network Capacity and Operational Flexibility

Access Spectrum has previously suggested that stakeholders consider merging the A Block with the PSBN spectrum. This combination would give FirstNet, working with its commercial partners and the public safety community, the flexibility to pursue a range of options that would benefit public safety. Access Spectrum has explained these public safety benefits in detail in comments submitted to FirstNet, which included a white paper prepared by Roberson & Associates.[7]

For instance, the additional spectrum provided by inclusion of the A Block could be used to augment the guard band between the PSBN Block and the 700 MHz public safety narrowband Block, thereby enhancing interference protection for public safety systems in both blocks. Another possibility would be to use the additional spectrum, as well as some repurposed 700 MHz public safety narrowband channels, to create a 2x5 MHz LTE block for the PSBN in addition to the existing 2x10 MHz LTE PSBN block. With these two options, FirstNet and key stakeholders would have discretion to enhance interference protection or broadband capacity depending on the specific circumstances in individual regions of the country, and also could move from one option to another as public safety communications needs and technology evolve

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the 698-746, 747-762 and 777-792 MHz Bands, Second Report and Order, 22 FCC Rcd 15289, ¶¶ 262-264 (2007).

[7] *See* Comments of Access Spectrum, *Development of the Nationwide Interoperable Public Safety Broadband Network*, NTIA Docket No. 120928505–2505–01, RIN 0660-XC002 (Nov. 9, 2012) (copy attached as Exhibit 1).

over time. Furthermore, as explained in the Roberson & Associates White Paper, adding the A Block could generate nearly $9 billion in additional revenues for the PSBN, thereby enhancing FirstNet's ability to build a robust PSBN in an expeditious manner.[8]

Including the A Block in the PSBN Block would, of course, obviate the need for rules to prevent interference between the PSBN and separate A Block operations. Access Spectrum is exploring this promising option with FirstNet and other stakeholders, but as described above is also aggressively pursuing the deployment of new commercial services and applications in the A Block. The Commission should consequently adopt appropriate technical safeguards to protect such commercial A Block services from interference.

IV. Conclusion

For the foregoing reasons, the Commission should adopt rules that protect licensees operating in the adjacent commercial channel blocks against harmful interference from the public safety broadband operations.

Respectfully submitted,

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May 24, 2013

[8] Both options are described in more detail in the attached White Paper, which was prepared last year by the technology consulting firm Roberson & Associates.

Exhibit 1

BEFORE THE
NATIONAL TELECOMMUNICATIONS AND INFORMATION ADMINISTRATION

Development of the Nationwide Interoperable Public Safety Broadband Network	)	
Notice of Inquiry on FirstNet Conceptual Network Architecture	)	Docket No. 120928505–2505–01 RIN 0660–XC002

COMMENTS OF ACCESS SPECTRUM, LLC

The First Responder Network Authority (FirstNet) has been charged with the critically important responsibility for establishing an interoperable, mobile broadband network that will serve the nation's first responders.[1] As one of the initial steps in carrying out this important duty, the National Telecommunications and Information Administration (NTIA), on behalf of FirstNet, has issued a Notice of Inquiry on a number of issues, including the "options that the FirstNet Board should consider in meeting the Act's requirements to deploy the [nationwide public safety broadband network (PSBN)] based on a single, nationwide network architecture that evolves with technological advancements."[2]

Access Spectrum, LLC (Access Spectrum), a licensee of the A Block, recommends that FirstNet and key stakeholders consider incorporating the Upper 700 MHz A-Block in the deployment of the PSBN. The Upper 700 MHz A-Block is a 2x1 MHz block of spectrum that is immediately adjacent to the PSBN spectrum block. Including the A Block in the PSBN deployment would provide FirstNet, its commercial partners, and the public safety community the flexibility to:

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[1] Section 6206 of the Middle Class Tax Relief and Job Creation Act of 2012, Pub. L. No. 112-96, 126 Stat. 156 (2012) (Act).

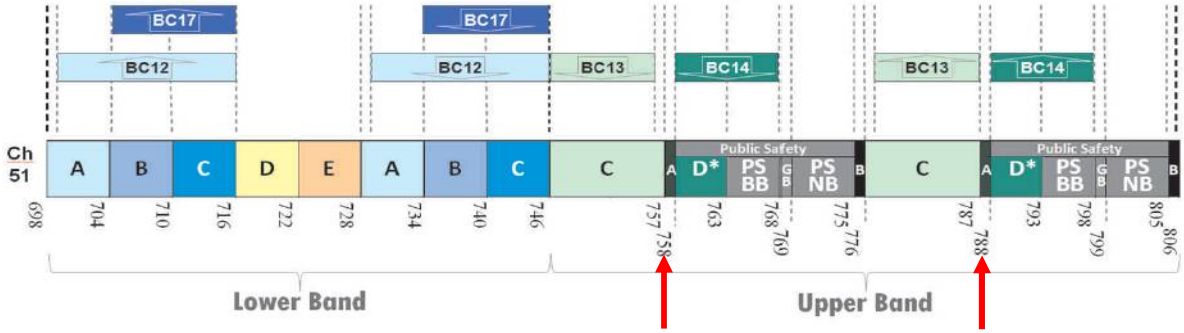
[2] *Development of the Nationwide Interoperable Public Safety Broadband Network,* Notice of Inquiry, Docket No. 120928505-2505-01 (Sept. 28, 2012) (NOI).

- Enhance interference protection while at the same time augmenting PSBN network capacity to meet first responder broadband communications needs both today and in the future
- Increase the efficient use of scarce, and very valuable, 700 MHz spectrum
- Facilitate interoperability across the upper 700 MHz band
- Substantially increase the value of the national investment in the PSBN, creating up to approximately **$9 billion** in additional economic value as estimated in the attached white paper

Access Spectrum has shared this idea with public safety entities, NTIA technical personnel, and a number of potential commercial partners, all of whom have agreed that the idea is worthy of additional exploration. Simultaneously, Access Spectrum has commissioned a technical trial aimed at demonstrating alternative uses for its spectrum (*e.g.*, control channel) consistent with potential interest expressed by other commercial entities and is engaged in periodic discussions with entities from multiple industries regarding the potential use of its spectrum. Access Spectrum submits these comments and the attached technical white paper to explain these significant public safety benefits and to recommend that the Request for Proposals (RFP) FirstNet will be issuing seek information and proposals for including the A Block in FirstNet's PSBN deployment.

I. Background

As the following diagram illustrates, the A Block is a 2x1 MHz block of spectrum situated between Upper 700 MHz C Block (licensed to Verizon Wireless) and the 2x10 MHz spectrum block that has been assigned to FirstNet to operate the PSBN.



Access Spectrum is one of three companies that holds licenses for the A Block throughout the United States.[3] Although Access Spectrum is exploring various opportunities and deployment options, the A Block is currently largely unutilized.[4] The A Block is highly valuable spectrum in the 700 MHz band, a band that has been recognized as having superior propagation characteristics well-suited for both public safety and commercial mobile broadband deployments. Verizon Wireless, AT&T, and a number of other wireless carriers are deploying LTE systems in both the upper and lower 700 MHz bands, and, of course, FirstNet will be deploying an LTE system in the PSBN block.

Prior to the Act's reassignment of the Upper 700 MHz D Block to FirstNet, a coalition of companies – including Sprint, T-Mobile, MetroPCS, Clearwire, the Rural Telecommunications Group, Access Spectrum, and Xanadoo – recommended that the A Block be combined with the Upper 700 MHz D Block.[5] These parties pointed out that combining these blocks would maximize the efficient use of this valuable spectrum and attract greater interest by commercial providers in partnering with a public safety broadband network.

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[3] The other two A Block licensees are BPC Spectrum LLC and Dominion 700 Inc.

[4] As stated above, Access Spectrum is currently preparing a control channel test and is engaged with several commercial entities that are considering using the spectrum for a variety of commercial applications. Should any of these activities progress, the A Block would no longer be available.

[5] *See, e.g.,* Letter from Connect Public Safety Now, to Marlene H. Dortch, FCC Secretary, WT Docket No. 06-150 (Dec. 2, 2010); Letter from the Coalition for 4G in America, to Marlene H. Dortch, FCC Secretary, WT Docket No. 06-150 (Aug. 4, 2010); Letter from the Coalition for 4G in America, to Marlene H. Dortch, FCC Secretary, WT Docket No. 06-150 (June 17, 2010); Letter from the Coalition for 4G in America, to Marlene H. Dortch, FCC Secretary, WT Docket No. 06-150 (Apr. 28, 2010).

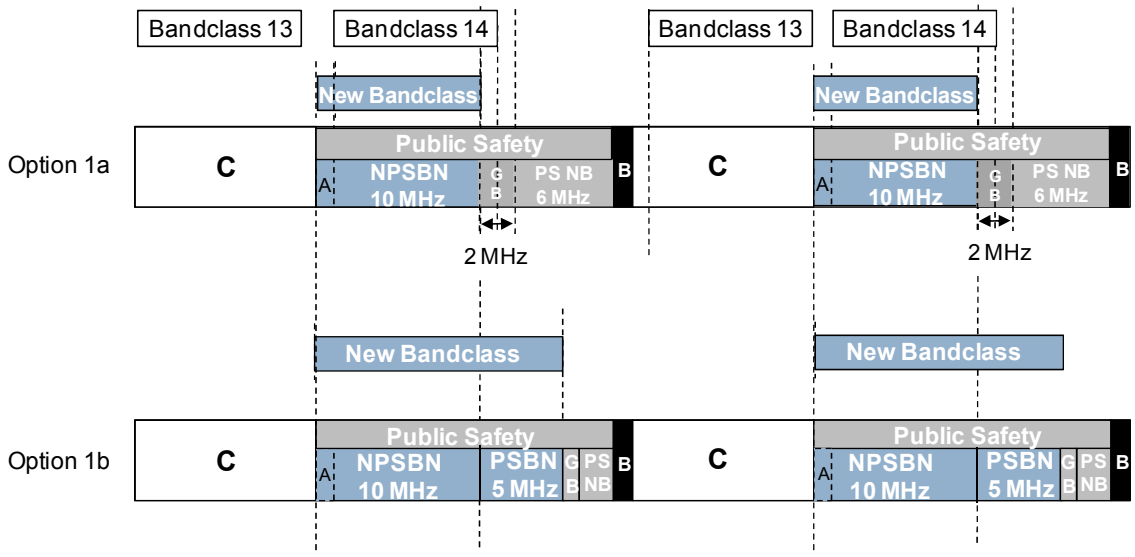
II. Combining the A Block with the PSBN Block Would Provide Significant Public Safety and Operational Benefits

With the assignment of the D Block to the PSBN block under the Act, Access Spectrum continues to believe combining the A Block with this adjacent block would result in significant benefits. To investigate these benefits further, Access Spectrum retained Roberson and Associates, LLC, a technology and management consulting company with extensive experience in spectrum and technology management. After careful analysis of a range of options, Roberson and Associates prepared the attached white paper which identifies very significant network enhancements and operational flexibility that would accrue to FirstNet if the A Block were included in the PSBN deployment. The white paper describes how the additional spectrum provided by the inclusion of the A Block can be used to enhance interference protection and deployment flexibility for 700 MHz band public safety services, *and/or* increase the broadband capacity of the PSBN.

In particular, the white paper recommends combining the A Block with the PSBN block to provide FirstNet and key stakeholders (including the public safety community and potential commercial partners of FirstNet) the flexibility to pursue the following options:

> Option 1a: Use the additional spectrum provided by the A Block to expand the guard band between the PSBN block and the 700 MHz public safety narrowband block from the current 2x1 MHz guard band to a 2x2 MHz guard band.
>
> Option 1b: Use the additional spectrum provided by the A Block as well as some repurposed 700 MHz public safety narrowband channels to create a 2x5 MHz LTE block for the PSBN in addition to the existing 2x10 MHz LTE PSBN block.

These two options are illustrated in the following band plan diagram:



With these two options, FirstNet and key stakeholders would have the flexibility to enhance interference protection or broadband capacity depending on the specific circumstances in each individual region of the country, and could also move from one option to another as public safety communications needs and technology evolve over time. For example, it may initially be beneficial in certain regions to expand the guard band by an extra megahertz, thus providing more interference protection to public safety narrowband systems and greater deployment and operational flexibility to the 2x10 MHz PSBN. Over time, however, many, if not all, regions may wish to create an additional 2x5 MHz LTE channel for the PSBN as public safety broadband demand increases. Creating this additional channel will require repurposing two-thirds of the existing 700 MHz narrowband channels, but this will be possible as technology progresses and the public safety community comes to rely on "voice-over-LTE" systems for mission critical voice communications and has less need for narrowband systems.

Implementing this proposal would not require legislation. Moreover, after FirstNet and key stakeholders have an opportunity to explore the benefits of the proposal, Access Spectrum and other A Block licensees can work with all relevant parties to develop an appropriate mechanism, under existing statutory authority, for compensating A Block licensees for

contributing their spectrum rights. For example, FirstNet or its commercial partners could acquire (or lease) the A Block licenses through the FCC license assignment process based on negotiated agreements with A Block licensees.

Access Spectrum encourages all interested parties to explore the advantages of combining the A Block with the PSBN block. Toward this end, FirstNet should seek comment on this proposed combination in the RFP it will be issuing to potential commercial partners interested in building, operating, and maintaining the PSBN. The RFP should invite parties to comment on the attached white paper or suggest alternative options for utilizing the A Block in conjunction with the PSBN deployment.

Access Spectrum strongly supports FirstNet's efforts to deploy expeditiously an effective, efficient PSBN that will serve the nation's public safety community, including by leveraging existing resources and infrastructure. This vital objective can be furthered by considering ways to make efficient use of the adjacent A Block spectrum as part of the PSBN.

Respectfully submitted,

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Application of the Upper 700 MHz A-Block To Public Safety

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Application of the Upper 700 MHz A-Block to Public Safety

Executive Summary

In February 2012, Congress passed landmark legislation to create a nationwide public safety broadband network (NPSBN). To achieve this objective, the legislation established the First Responder Network Authority (FirstNet), an independent authority within the National Telecommunications & Information Administration (NTIA). FirstNet will hold the spectrum license for the NPSBN and is charged with taking "all actions necessary" to build, deploy, and operate the NPSBN. FirstNet has initiated the process of carrying out this statutory mandate and will be consulting with the public safety community, the wireless industry, and other key stakeholders to develop an effective framework for providing interoperable broadband communications to first responders throughout the country.

This paper recommends that FirstNet and key stakeholders consider incorporating the upper 700 MHz A-Block spectrum in the framework for establishing the NPSBN. The upper 700 MHz A-Block is a 2x1 MHz block of spectrum that is directly adjacent to the 2x10 MHz block of spectrum that has been assigned to FirstNet to operate the NPSBN. At the current time, the A-Block is largely unutilized.[1] Combining the A-Block with the NPSBN allocation could significantly increase the network capacity of the NPSBN and/or provide greater interference protection and deployment flexibility for the NPSBN and public safety narrowband systems in the 700 MHz band, unlocking economic benefits of up to approximately $9 billion.

Incorporating the A-Block would enhance FirstNet's flexibility to add broadband capacity and/or greater interference protection as public safety communications needs evolve over time. Under this option, the NPSBN would deploy a base 2x10 MHz LTE configuration, the 700 MHz public safety narrowband allocation would initially remain the same, and the guardband between the NPSBN and narrowband blocks would be expanded to 2x2 MHz in order to provide additional interference protection and deployment flexibility. Over time, however, the public safety community in some or all regions of the country may determine that there is greater need for additional broadband and less of a need for narrowband channels, particularly as public safety agencies evolve towards relying on LTE to meet their voice communications needs. This evolution will allow the repurposing of some of the 700 MHz band narrowband spectrum for broadband use if and when public safety chooses. With such a repurposing, along with the addition of the A-Block spectrum, the NPSBN could deploy an additional 2x5 MHz LTE carrier in the regions in question while still maintaining some narrowband channels. The additional 2x5 MHz LTE channel would support the

[1] Access Spectrum is currently preparing a control channel test and is engaged with several commercial entities that are considering using the spectrum for a variety of commercial applications. Should any of these activities progress, the A-Block would no longer be available.

public safety community's expanding need for broadband communications over time, including future mission critical voice over LTE.

This paper provides a detailed analysis of the proposal described above, describing its benefits, costs, impact, and corresponding value. We believe this proposal would maximize FirstNet's flexibility to use the A-Block spectrum to expand the guardband or add broadband capacity to meet public safety communications needs as these needs evolve by region and over time. Implementing this proposal would not affect ongoing commercial network operations in the upper 700 MHz band, and is consistent with 3GPP technical standards. The only modification is an expanded definition of 3GPP band class 14.

As FirstNet develops a framework for deploying the NPSBN, it has a unique opportunity to consider the significant benefits of incorporating the upper 700 MHz A-Block as part of that deployment. FirstNet will be issuing Requests for Proposals (RFPs) from suppliers and mobile network operators interested in partnering with FirstNet in constructing and operating the NPSBN. As part of these RFPs, FirstNet should seek comment on how best to incorporate the A-Block in the NPSBN deployment.

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1.0 Introduction

1.1 Nationwide Public Safety Broadband Network

It is of the highest national urgency to deploy an effective Nationwide Public Safety Broadband Network (NPSBN).[2] To this end, Congress directed the FCC to reallocate the 700 MHz D-Block to public safety use,[3] commissioned the FCC to develop the minimum technical requirements to ensure a nationwide level of interoperability for the Nationwide Public Safety Broadband Network, and authorized the creation of FirstNet, within the NTIA, as the governing entity for that network.[4] Based on the reallocation of the D-Block, the amount of public safety broadband spectrum is now 2x10 MHz. Whereas this spectrum is expected to meet the foreseen needs of the public safety community for normal and emergency situations, the anticipation of broadband applications growth and new applications dictates that reasonable, additional approaches to increasing the public safety broadband capacity be explored. Interoperability across the 700 MHz band has also been recognized as a highly desirable but yet-to-be achieved goal.[5] Finally, because of the recognized high value of 700 MHz spectrum, it is necessary to seek methods to use spectrum as efficiently as possible. As the planning of the NPSBN commences under FirstNet, it is therefore worthwhile to explore additional options for providing additional capacity and enabling interoperability consistent with the mission critical role of public safety.

1.2 The 700 MHz A-Block

A viable alternative to addressing the public safety needs of increased broadband capacity, flexible deployment options, spectrum efficiency, and interoperability is to augment the public safety broadband spectrum with adjacent spectrum blocks, just as the original 2x5 MHz public safety broadband spectrum has been augmented with the addition of the adjacent D-Block.

Figure 1.1 is a diagram of the upper 700 MHz band, taken from the FCC NPRM on 700 MHz Interoperability.[6] It can be seen that the upper 700 MHz A-Block (757-758 and 787-788 MHz) is immediately adjacent to the public safety uplink and downlink broadband allocation consisting of the combined D-Block and original public safety broadband spectrum, and is therefore an excellent candidate in this regard. The A-Block is largely unutilized across the country, consistent with the NPSBN spectrum and plan, and the licenses are held by only three entities.

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[2] *See Connecting America: The National Broadband Plan*, The Federal Communications Commission, Chapter 16 (Mar. 2010), *available at* http://www.broadband.gov/download-plan/ (*National Broadband Plan*.

[3] *See Middle Class Tax Relief and Job Creation Act of 2012, Title VI – Public Safety Communications and Electromagnetic Spectrum Auctions/(Spectrum Act)*

[4] *See* http://www.ntia.doc.gov/category/public-safety / (FirstNet Announcement)

[5] *See* FCC *Notice of Proposed Rulemaking, WT Docket No. 12-69, Promoting Interoperability in the 700 MHz Commercial Spectrum,* March 21, 2012, paragraph 46. /(FCC NPRM on Interoperability)

[6] *See FCC NPRM on Interoperability* at paragraph 6.

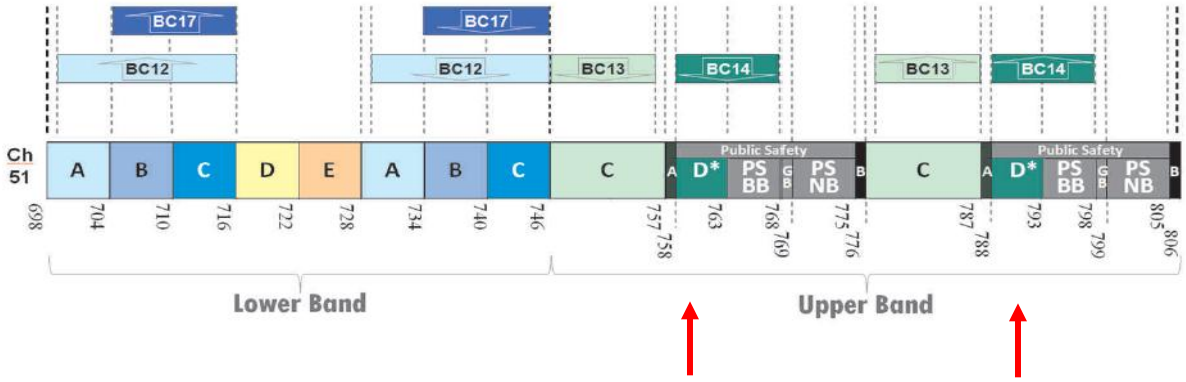

Figure 1.1: 700 MHz Spectrum and Upper 700 MHz A-Block

1.3 Purpose and Organization of the White Paper

This study puts forth and discusses the technical aspects of incorporating the upper 700 MHz A-Block spectrum with the 2x10 MHz public safety broadband allocation to provide FirstNet additional flexibility to increase the NPSBN's broadband capacity and/or expand the guardband between with the NPSBN block and the public safety narrowband block. In addition to this recommendation, we have considered a number of other options that are discussed in Appendix D to this white paper. Our recommended approach, as well as each of the options discussed in Appendix D, would benefit public safety users by addressing critical public safety needs. This white paper offers a framework for consideration and analysis by FirstNet, the broader public interest community, and potential commercial partners in the context of the Request for Proposals (RFPs) that will be issued by FirstNet to advance the NPSBN deployment.[7]

Section 2 of the white paper covers the scope and the context for the development of the band plan proposal, including the parameters, constraints, and assumptions for generating and evaluating it. The requirements of a NPSBN relevant to the goals of interoperability and performance are also covered in Section 2. Section 3 describes the recommendation for including the A-Block with the public safety broadband spectrum that have been analyzed and are proposed for consideration by FirstNet. This section also summarizes the value provided by this white paper's proposal, and the impact on public safety users and stakeholders, and on 3GPP standards. Section 4 provides a summary of the recommendation based on the criteria and goals set forth in Section 2. An assessment of the economic value of the proposal also is included in Section 4. Section 5 states the overall conclusions and recommendations for moving forward on the band plan proposal

[7] *See FirstNet Announcement, and First Responder Network Authority, Board of Directors Recruitment Prospectus,* page 3.

described. The actions required to realize the band plan proposal, including steps necessary in the 3GPP standards process, the FCC, and public safety area are also described in Section 5.

2.0 Constraints and Requirements

In developing options and recommendations for combining the upper 700 MHz A-Block with public safety broadband spectrum, the following key criteria were employed:

- Minimal or no impact on existing 700 MHz commercial systems.
- Manageable impact on 700 MHz public safety operations.
    - Any impact balanced by increased value to public safety.
- Address current requirements and anticipate future NPSBN needs (e.g. interoperability, applications growth, voice over LTE).[8]
- Operate within existing 3GPP standards and standards evolution.
- Support FCC rules and initiatives (e.g. 700 MHz interoperability).[9]

This set of criteria is more restrictive than the criteria used in previous studies of the use of the A-Block by public safety,[10] with the expectation that highly practical solution options will result. At the same time, the criteria also focus on increased value to public safety and FCC directions, and are consistent with the 3GPP LTE basic standards.

2.1 700 MHz Commercial Systems

We viewed approaches that increased the opportunity for interoperability between public safety and commercial networks to be valuable to both stakeholder communities. On the other hand, band plan options that would affect existing commercial networks or user equipment were not considered.

2.2 Public Safety Operations

Many public safety agencies and suppliers have investments in 700 MHz narrowband systems and some have made early investments in 700 MHz broadband systems and components.[11] While the addition of the upper 700 MHz A-Block to the public safety spectrum inventory does impact public

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[8] *See Final Report, Recommended Minimum Technical Requirements to Ensure Nationwide Interoperability for the Nationwide Public Safety Broadband Network*, prepared by the Technical Advisory Board for First Responder Interoperability, May 22, 2012; and FCC WTB Workshop on Interoperability, available at http://www.fcc.gov/events/700-mhz-interoperability-workshop, April 26, 2011/ (*FCC Interoperability Report*).

[9] *See FCC NPRM on Interoperability* at paragraph 46.

[10] *See Comments of Xanadoo Company*, PS Docket 12-74, May 31, 2012, and *Ex Parte Presentation Re: WT Docket Nos. 96-86 and 06-150 and PS Docket No. 06-229*, Lawler, Metzger, Keeney & Logan, LLC, Nov. 7, 2011.

[11] *See Discussion of 700 MHz Spectrum Policy Issues for Public Safety in King County*, prepared by Hatfield and Dawson Consulting Engineers, LLC, with NetCity, Inc., Dec 20, 2010, available at http://transitwireless.org/information-topics/700-mhz-band-d-block/(*King County Discussion*), and *Letter to Hon. Julius Genachowski, Chairman, Federal Communications Commission*, from Chief Harlan R. McEwen, International Association of Chiefs of Police, PS Docket No. 06-229, filed Oct. 12, 2009 (stating "Public Safety Radio Communications-Wireless Broadband is not an Alternative to LMR Mission Critical Voice Systems")(*McEwen Letter*).

safety stakeholders, the augmentation of the original 2x5 MHz public safety broadband with the 2x5 MHz D-block, coupled with further augmentation with the A-Block, creates opportunities for FirstNet to explore new spectrum utilization approaches that would significantly benefit public safety in the future. In a recent Order,[12] the FCC similarly recognizes the need to allow FirstNet to have full decision making authority in its role as architect of the public safety nationwide network, allowing previously granted waiver rights to 21 public safety agencies to lease 700 MHz spectrum to expire.

With regard to the public safety narrowband spectrum and current and future deployments, the expectation is that over time, mission critical voice over LTE will be able to supply most of the voice services of public safety, including a portion of those services that require off-network, or direct unit-to-unit communication.[13] In fact, several public safety agencies have proposed utilizing the public safety narrowband spectrum in their broadband network deployments.[14] Moreover, Section 6102 of the Spectrum Act allows the public safety narrowband spectrum to be repurposed for broadband use upon approval by the FCC. For these reasons, approaches that reduce the amount of public safety narrowband capacity in order provide for additional broadband capacity options have been considered as viable and important to consider in anticipating future public safety needs. Nevertheless, it is expected that the need for some level of public safety narrowband capacity will exist at least for the next 10 to 15 years.[15]

Since voice over LTE is significantly more spectrally efficient than traditional narrowband voice, future migration of as many voice services as possible to mission critical voice over LTE would increase the aggregate amount of voice capacity available to public safety. A study item within 3GPP for direct unit-to-unit, non-networked operation using LTE has been active since June 2012 for LTE Release 12.[16] It is targeted to both mission critical public safety and commercial operating scenarios, and functions both within and outside of the coverage area of an LTE network. It is anticipated that most if not all of public safety narrowband operations could be transitioned to use LTE in the future.

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[12] *See* Order, In the Matter of Implementing Public Safety Broadband Provisions of the Middle Class Tax Relieved and Jobs Creation Act of 2012. PS Docket No. 12-94, FCC 12-85, July 31, 2012.
[13] *See King County Discussion* at page 18, and 3G Partnership Project, *Feasibility Study for Proximity Services (ProSe) (Release 12), TR22.803*, http://www.3gpp.org/ftp/Specs/html-info/22803.htm.
[14] *See* (1) City of New York Petition for Waiver, PS Docket No. 06-229, filed Jun. 8, 2009; (2) City of Boston Amended Request for Waiver, PS Docket No. 06-229, filed May 28, 2009; (3) State of New Jersey Petition for Waiver, PS Docket No. 06-229, filed Apr. 3, 2009; *and* (4) State of North Dakota Petition for Waiver, PS Docket No. 06-229, filed Jul. 17, 2009.
[15] *See McEwen Letter.*
[16] *See* 3G Partnership Project, *Feasibility Study for Proximity Services (ProSe) (Release 12), TR22.803*, http://www.3gpp.org/ftp/Specs/html-info/22803.htm (*Proximity Services*).

2.3 Public Safety Requirements, Challenges, and Needs

An assessment of the current and future public safety requirements for the National Public Safety Broadband Network (NPSBN) was made based on the GAO report,[17] FCC Interoperability Report,[18] and public safety studies.[19]

Key public safety requirements from these documents, the result of efforts of the public safety stakeholder community, include:

1. Ensure interoperability.
2. Provide and increase spectral efficiency.
3. Ensure standards are used.
4. Provide a roadmap and make provisions for future public safety needs.

These attributes were among those used to evaluate the proposal in the study.

2.4 3GPP Standards: LTE

The FCC, with the full support of the public safety user and supplier community, has ruled that LTE will be the standard technology for Public Safety broadband deployments in the 700 MHz band.[20] Since commercial operators have also decided to deploy LTE in the 700 MHz band, a key criterion for the band plan proposal is that it be consistent with current LTE standards. Per the *FCC Interoperability Report*, LTE Release 9 is considered the baseline for the proposal in this study.

In particular, LTE standards define operations in a set of standard frequency bands as indicated in Table 2.1.[21]

Table 2.1: Standard LTE Bands

MHz	1.4	3	5	10	15	20
Eff. BW	1.08	2.7	4.5	9	13.5	18

Only band plan options that utilize these standard operating frequency bands were considered in this study.

[17] See. GAO *Emergency Communications – Various challenges Likely to Slow Implementation of a Public Safety Broadband Network*, Feb 2012, available at http://www.gao.gov/products/GAO-12-343.
[18] *See FCC Interoperability Report.*
[19] *See* National Public Safety Telecommunications Council, *Public Safety 700 MHz Broadband Statement of Requirements* (2007).
[20] *See FCC, Implementing a Nationwide, Broadband, Interoperable Public Safety Network in the 700 MHz Band*, January, 25, 2011, available at http://www.fcc.gov/document/implementing-nationwide-broadband-interoperable-public-safety-network-700-mhz-band-5.
[21] *See 3GPP Technical Specifications, TS36.101, Evolved Universal Terrestrial Radio Access (E-UTRA): User Equipment (UE) Radio Transmission and Reception, v9.7.0,* page 48.

The LTE standards release schedule (LTE Advanced) goes beyond the capabilities in Release 9 and provides capabilities that will be valuable to the NPSBN. Carrier aggregation is a new capability that combines the capacity and throughput capability of separate LTE carriers.[22] With the additional bandwidth afforded by the A-Block, carrier aggregation can be used to advantage to provide for additional public safety broadband capacity. Carrier aggregation allows the capacity and throughput of two or more LTE carriers and separate spectrum blocks to be seamlessly combined and scheduled as single entity. For public safety, this allows the capability of two LTE carriers to be combined. Band plan options that make use of this future LTE capability were therefore included in the study and are described in Appendix D.

Furthermore, it is recognized that 700 MHz interoperability between the NPSBN and commercial networks would be greatly facilitated by a band plan that provides for a uniform deployment of LTE in the upper 700 MHz region.[23] Inclusion of the A-Block with the public safety broadband spectrum, with corresponding definition of a new LTE band class for public safety, opens the door for such interoperability, as will be shown in Sections 3 and 4. Because of the value of interoperability, as well as the very advantageous economies of scale for public safety broadband equipment that it would enable by allowing user equipment to operate seamlessly across the upper 700 MHz band, this change to the 3GPP standard was considered justifiable.

2.5 FCC Directions: Interoperability

The corresponding band classes for operations in the 700 MHz spectrum are indicated in Figure 1.1. There is a continuing set of initiatives to define a common unified lower 700 MHz band.[24] In the context of FCC inquiries, many commenters have advocated for an interoperability requirement across the entire upper and lower 700 MHz bands.[25] Therefore, band plan options that facilitated interoperability in the upper 700 MHz band were sought and evaluated.

3.0 Band Plan Proposal

This section describes a recommended option for combining the upper 700 MHz A-Block with the public safety broadband spectrum, given the constraints, goals, and requirements outlined in Section 2. Other approaches and variations are possible, and the option presented here and the alternatives presented in Appendix D should not be viewed as the only ones that should be considered. Feedback and discussion of this option are invited and expected to result in the development of additional valuable approaches. It is for this reason that FirstNet should require

[22] *See 3GPP Technical Specification, TS36.808, Evolved Universal Terrestrial Radio Access (E-UTRA): Carrier Aggregation,* and *3GPP Technical Specification, TS36.823, Evolved Universal Terrestrial Radio Access (E-UTRA): Carrier Aggregation Enhancements.*
[23] *See FCC Interoperability Report,* and *T-Mobile Written Ex Parte Communications, RM-11592, WT Docket 06-150*, March 13, 2012 /(*T-Mobile ex parte*).
[24] *See FCC NPRM on Interoperability.*
[25] See *T-Mobile ex parte,* for example.

consideration of the use of the A-Block in RFPs that it issues under its authority to architect and deploy the NPSBN.[26]

Band Plan Description

This recommended option would add the 2x1 MHz Upper A-Block spectrum to the NPSBN allocation. The public safety broadband spectrum band edge would be shifted 1 MHz lower to include the A-Block and create a contiguous block of spectrum with the upper C-block in which LTE can be deployed. The addition of the A-Block would give FirstNet two options: (1) expand the guardband between the NPSBN block and the public safety narrowband block from the current 2x1 MHz to 2x2 MHz; or (2) create an additional 2x5 MHz NPSBN LTE block by repurposing 2x4 MHz of the 2x6 MHz public safety narrowband spectrum block for broadband use and combining this repurposed spectrum with the A-Block. Figure 3.1 illustrates these options and also shows the relationship of the current 3GPP band classes and proposed new band classes.

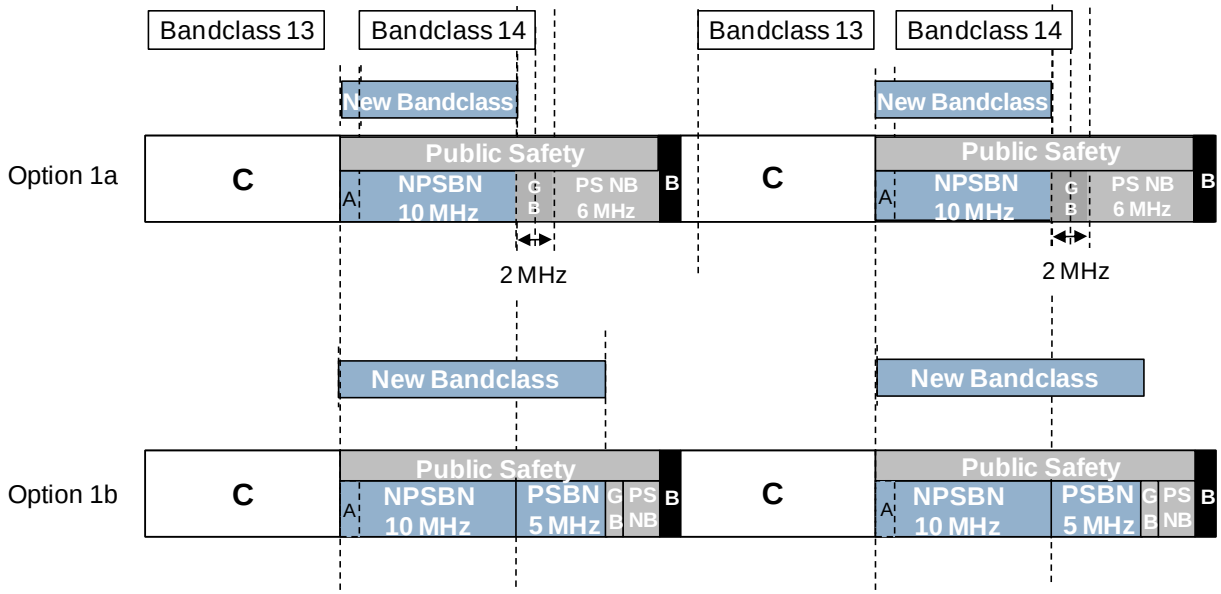

Figure 3.1 Deployment Flexibility Approach

Value

Overview. Under both Options 1a and 1b, FirstNet would maintain the current plan to deploy a 2x10MHz LTE system for the NPSBN, and the guardband between the NPSBN block and the narrowband block would remain *at least* 2x1 MHz. The addition of the A-Block spectrum, however, would give FirstNet significant additional flexibility to expand the guardband to provide additional interference protection and deployment flexibility (Option 1a), or to enhance the broadband capacity of the NPSBN by adding a 2x5 MHz LTE block (Option 1b). The choice between the two options could vary by region and over time. In some regions there may be less of a need for

[26] Combination of the A-Block with the existing public safety broadband spectrum would of course require FirstNet or its commercial partner(s) to acquire license rights for the upper 700 MHz A-block.

narrowband channels, in which case some of these channels can be repurposed for broadband use and combined with the spectrum made available by the addition of the A-Block to create the new 2x5 MHz LTE block. Over time, more regions could similarly repurpose narrowband spectrum to broadband as public safety systems come to rely more on LTE to meet mission critical voice needs (as discussed in section 2.2 above). The deployment envisioned by Option 1b could thus ultimately extend throughout the country. The addition of the A-Block would thus give FirstNet and the public safety community greater flexibility to meet their interference protection and broadband capacity requirements as their needs evolve by region and over time.

Benefits of Expanded Guardband (Option 1a). The purpose of the existing 2x1 MHz internal public safety guardband is twofold: to protect traditional noise limited land mobile radio (LMR) systems from out-of- band emissions (OOBE) of adjacent broadband networks (primarily base stations), and to protect broadband systems from OOBE of higher-powered LMR transmitters (see Appendix A). As would be expected, a larger guardband provides increased interference protection to narrowband systems due to broadband OOBE. It is noted that the Verizon operations in the upper 700 MHz C-block incorporate an additional 1 MHz of guardband adjacent to the upper A-Block in the downlink and the upper B block in the uplink. Increasing the guardband to 2x2 MHz for public safety would create the same protection as provided by band class 13, further relaxing any narrowband/broadband frequency coordination and planning requirements, and might allow closer geographic deployments of narrowband and broadband systems. An increased guardband would also relax any radiated power limitations on public safety broadband equipment, potentially resulting in higher throughput, particularly at the broadband cell edge. Again, since FirstNet and the local public safety agencies are responsible for broadband and narrow band operations, advantages that accrue to increased interference protection can be realized effectively and practically.

Benefits of Expanding Broadband Capacity (Option 1b). Option 1b would maximize the amount of public safety spectrum for broadband applications and provide 50% more capacity than the existing 2x10 MHz block. A primary application of this additional broadband capacity would be a significant increase in the number of broadband data users and services that can be supported, and a significantly reduced (or eliminated) reliance on commercial networks for additional capacity. This increase in broadband data services could be coupled with a future phase-in and migration, from narrowband spectrum, of those mission critical voice services suitable for LTE operation. This would enable the creation of integrated "voice plus broadband data" public safety user devices.
Option 1b further allows for separate 2x10 and 2x5 MHz LTE carriers to be independently deployed on a shared infrastructure, resulting in increased options for local agency/nationwide network deployment, effective handling of emergency/disaster situations, and sharing of the broadband network for other "critical infrastructure" uses such as public utilities.[27]

[27] *See Reply Comments of National Rural Electric Cooperative Association*, WT Docket No. 06-150, Service Rules for the 698-746, 747-762 and 777-792 Bands, and PS Docket No. 06-229, Implementing a Nationwide, Broadband Interoperable Public Safety Network in the 700 MHz Band, May 10, 2011/ (*NRECA Reply Comments*).

Interoperability Benefits. Under either Option 1a or 1b, the addition of the A-Block to the public safety broadband spectrum would create a contiguous LTE spectrum region (the upper 700 MHz C-Block, A-Block, and current public safety broadband block) that facilitates interoperability, and creates additional economies of scale opportunities for public safety equipment.

Impact

Shifting and expanding the public safety broadband spectrum allocation would at minimum require redefining 3GPP band class 14, and modification of the RF portions of transceiver equipment and components already proposed for public safety. Creation of a new 3GPP band class for public safety in the upper 700 MHz band would require additional 3GPP standards development.

Option 1b would reduce the number of the 700 MHz public safety narrowband block by 2x4 MHz, or 640 duplex narrowband channels out of a total of 960. Since it is recognized that not all mission critical voice communications may able to be accomplished by LTE, Option 1b would retain a total of 320 narrowband channel pairs for this type of operation, and for backward compatibility with legacy narrowband equipment. Repurposing 700 MHz narrowband spectrum for broadband use would require FCC approval. Option 1b would also require re-assignment of channels of any narrowband equipment that is already deployed or planned for deployment in 700 MHz narrowband spectrum. Trading-off narrowband capacity for broadband capacity will be increasingly important in the future, however, as the capability for mission critical voice is developed,[28] and the use of broadband applications intensifies. The other option for public safety to consider is to further consolidate public safety narrowband operations in the VHF, UHF, and the 800 MHz bands where a significant amount of spectrum is available (see Appendix B).

Appropriate frequency coordination in the geographic border areas between regions that have elected different deployment options would be necessary. For example, geographic separation between the regions where the additional broadband capacity (2x5 MHz) and the full narrowband channel set (960 channels) is employed must be maintained. There has been an ongoing discussion on flexible use of the public safety narrowband spectrum within the FCC and industry,[29] and the approach proposed here is a potential method for realizing that goal. This approach further provides for the future transition of public safety narrowband operations to LTE-based mission critical voice communications.[30]

4.0 Evaluation of the Band Plan Proposal

In this section, an evaluation of the band plan proposal is presented using the criteria described in Section 2, which emphasize attributes of importance to public safety users. The proposal provides

[28] *See* IPWireless, *LTE addressing the needs of the public safety community*, RWS-120030, 3GPP RAN Workshop on Rel-12 and Onward, June 11-12, 2012.
[29] *See FCC Request for Comment on the Technical and Operational Feasibility of Enabling Flexible Use of the 700 MHz Public Safety Narrowband Allocation and Guardband for Broadband Services*, PS Docket No. 06-229, DA 10-877, Sep.28, 2010.
[30] See *Proximity Services.*

increased value to public safety and the NPSBN. It also creates contiguous regions of uplink and downlink spectrum, together with the upper 700 MHz C block, in which LTE can be deployed. Use of LTE in the A-Block removes any carrier uncertainty or concerns about potentially non-compatible technology being deployed there in the future as any systems deployed in the A-Block must be afforded the same protections as the Upper 700 C Block.[31] Further, this plan facilitates the development of economical user devices that operate seamlessly across the upper 700 MHz band, a highly desirable goal of the NPSBN and FCC.

4.1 Broadband Capacity, Impact on Narrowband Operations, and Future Needs

The recommended band plan proposal enables an expanded internal guardband to provide greater interference protection where needed, but over time allows for the creation of a new broadband spectrum block as public safety agencies evolve towards the use of LTE to support mission critical voice, lessening the need for narrowband channels. This option thus provides corresponding weighted broadband and narrowband capacities depending upon the deployment distributions and the particular communications needs of each region. It also provides a roadmap for flexible use of narrowband spectrum for broadband that can be local and regional agency specific. This recommended option further provides for the future migration of narrowband voice to mission critical, direct unit-to-unit voice over LTE.

4.3 Deployment Approaches

The proposal, as well as the additional options discussed in Appendix D, utilize 3GPP LTE standards and architecture, and would take advantage of future LTE capabilities such as carrier aggregation.

4.4 Economic Value

The addition of the A-Block spectrum to the existing public safety broadband spectrum creates a broadband capacity increase. One method of assessing the economic value of the capacity increase is to determine the lease value of the added capacity.[32] This value could be obtained by leasing the additional capacity to critical infrastructure users such as utilities, or to commercial entities. The expectation is that in normal daily operations, the public safety broadband network will be lightly loaded as compared to its capacity. A previous study[33] has shown that the public safety network can be shared with non-public safety users *without* compromising the priority requirements of the public safety community. During emergency situations, public safety users can be guaranteed expanded access to the network.

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[31] *See Second Report and Order, FCC 07-132, WT Docket No. 06-150, Service Rules for the 698-746, 747-762 and 777-792 MHz Band,* paragraphs 261-264.

[32] *See* Kolodzy, P and Bazelon, C, *Employing the Upper 700 MHz A-Block to Reduce Construction and Operations Costs for the Public Safety Broadband Network,* September 23, 2011. http://apps.fcc.gov/ecfs/document/view;jsessionid=ryT7PSbW1lTtCQN3nGB3x5FlSQ7BPnCf7TpP6hG2Tqnd2JTrX0h3!1471562840!-321460796?id=7021746371

[33] *See Roberson and Associates, White paper: Public Safety Priority Access to Shared Commercial Networks*, Mar 3, 2011. http://fjallfoss.fcc.gov/ecfs/document/view?id=7021033056

A detailed analysis of adding 1.4 MHz spectrum to an existing 10 MHz public safety broadband spectrum block is available in Table 1 of a previous cost study,[34] based on the foundation provided by FCC for estimating the CAPEX and OPEX for the nationwide broadband network.[35] Applying the same methodology to the recommendation described in this study provides an estimate of its financial value.

The 2x10 MHz base broadband network is considered a reference for estimating the additional revenues, assuming a 10-year period as was done in the previous study (see Appendix C). Using this reference, Option 1(b) would yield additional revenue of approximately $8.8 billion, assuming FirstNet and key stakeholders deployed Option 1(b) throughout the 10-year period. If Option 1(a) and Option 1(b) were deployed on a 50%/50% basis during the 10-year period, the additional revenue would amount to approximately $4.4 billion. In this latter scenario, FirstNet and key stakeholders would be relinquishing a portion of the additional revenue in return for the added value of maintaining a larger number of public safety narrowband channels for a longer period of time and enhanced interference protection through an expanded guardband.

A highly simplified approach can also be used to verify that the more detailed analysis is realistic. Assume a core of 2M public safety users for the NPSBN, and a $70/month cost per user for the network, which would be an approximate commercial rate for an equivalent broadband wireless service. Assuming a 50% deployment of each of the options within Option 1, the revenue generation potential for that proposal would be $4.1B. A 100% deployment of Option 1(b) would yield an estimated $8.2 billion in additional revenue.

Both the simplified and detailed calculation methods, while yielding slightly different results, confirm a significant added value for combining the upper 700 MHz A-Block with the public safety broadband spectrum.

Should FirstNet and its commercial partner(s) determine that an alternative use of the A-Block delivers a greater economic benefit, it would have the flexibility to choose that approach, so the spectrum leasing valuation method should be viewed as the floor for the value of the incremental spectrum. That said, it is not our intent to take a position on the precise value of the spectrum as we are not the best parties to assess the highest and best use for this spectrum. However, these estimates highlight the potential value of this addition to the FirstNet spectrum and reinforce the need to require consideration of the use of the A-Block in RFPs that it issues under its authority to architect and deploy the NPSBN.

[34] *See Kolodzy et al.*

[35] *See* Federal Communications Commission, Omnibus Broadband Initiative, *A Broadband Network Cost Model: A Basis for Public Spending Essential to Bringing Nationwide Interoperable Communications to America's First responders,* 2010, http://transition.fcc.gov/pshs/docs/ps-bb-cost-model.pdf.

5.0 Conclusions and Recommendations

5.1 Conclusions

The addition of the upper 700 MHz A-Block to the current public safety 2x10 MHz broadband spectrum creates valuable and practical band plan options for increased public safety broadband capacity, accommodating future broadband applications such as mission critical voice over LTE, and more flexible broadband/narrowband deployment options. Creation of contiguous spectrum blocks for LTE across public safety and commercial networks in the upper 700 MHz band opens the door for more efficient and economical interoperability between public safety and commercial networks in the upper 700 MHz band. It is expected that upon acceptance of a proposal of interest, FirstNet or its commercial partner(s) would need to acquire the upper 700 MHz A-block to achieve the benefits described in this paper.

5.2 Recommendations: Band Plan

Maximum Public Safety Broadband Capacity /Flexible Use

If it is determined by further analysis by the public safety stakeholder community to provide for the greatest amount of public safety broadband capacity in the future, as well as the option for flexible deployment of narrowband spectrum for broadband use on a regional basis, then the proposal described herein should be included in the NPSBN roadmap. As described above, enabling this option via FCC rule changes, 3GPP band class changes, and corresponding equipment changes would allow different public safety regional jurisdictions to flexibly use the public safety narrowband spectrum for broadband operations or narrowband operations, as indicated by local needs. It is also clear that if public safety decides that this option is viable, then future transitioning narrowband voice operations to LTE, or consolidating narrowband LMR operations in the allocated VHF, UHF, 800 MHz, and remaining 700 MHz narrowband spectrum region, is required.

5.3 Recommendations: FirstNet

Because of the considerable value afforded by combining the upper 700 MHz A-Block with the public safety broadband spectrum, consideration for how the A-Block can best be accommodated in the NPSBN and roadmap should be a requirement in Requests for Proposal issued by FirstNet. The views of public safety agencies, user groups, and suppliers should also be sought to determine which approaches provide maximum future value to public safety users.

As stated earlier, the option recommended in this study (as well as those described in Appendix D) are representative ones for leveraging the advantageous location of the upper 700 MHz A-block adjacent to the public safety broadband spectrum. As the FirstNet and the public safety community evaluate the financial and operational benefits for augmenting the public safety spectrum with the upper A-block, additional and alternate proposals may also evolve during the analysis. This study creates a framework for discussion of such proposals and facilitates the generation of solutions which will provide significant value to the public safety agencies who are the primary users of the national public safety broadband network.

Appendix A: Public Safety Guardband

The Public Safety Guardband (PS GB) is a 2x1 MHz (768-769 and 798-799 MHz) band defined between the Public Safety Broad Band (PSBB) and Public Safety Narrow Band (PSNB) spectrum, primarily to protect narrowband public safety users against broadband Out Of Band Emission (OOBE) interference. PSBB LTE UE Tx Adjacent Channel Leakage Ratio (ACLR) may leak into LMR channel and raise the noise floor of the LMR fixed stations. LTE and LMR use different RF Specifications in Transmit Power. The typical mask for an LTE system is shown in Figure A.1.[36]

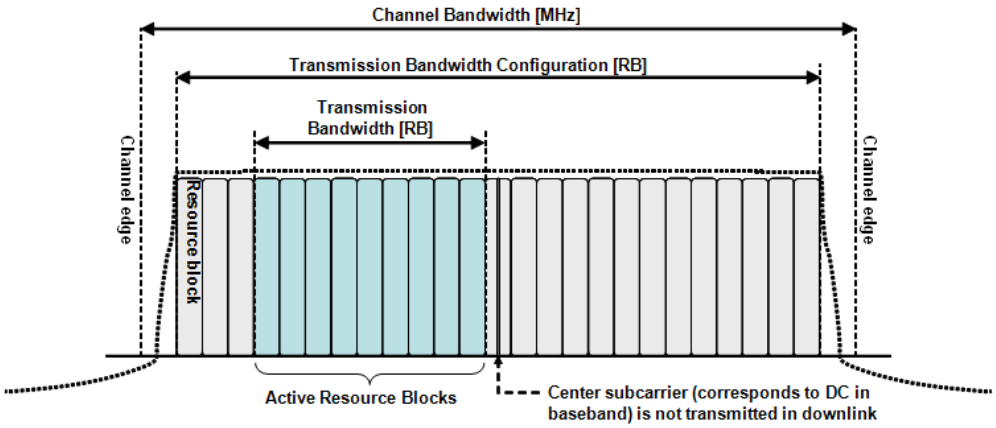

Figure A.1: Typical LTE Spectrum Mask

LMR systems are noise limited whereas cellular broadband networks are generally interference limited. This implies that they can tolerate more interference than LMR. The typical OOBE interference manifests itself as addition noise floor for narrow band LMR systems as indicated in Figure A.2[37]

[36] *See E-UTRAN: Base Station (BS) Radio Transmission and Reception,* TS 361104-9c0, www.3gpp.org
[37] *See* CSMAC, *Interference and dynamic spectrum access subcommittee, Interim Report*, May 19, 2010, http://www.ntia.doc.gov/files/ntia/meetings/csmac_may19_idsa_final.pdf

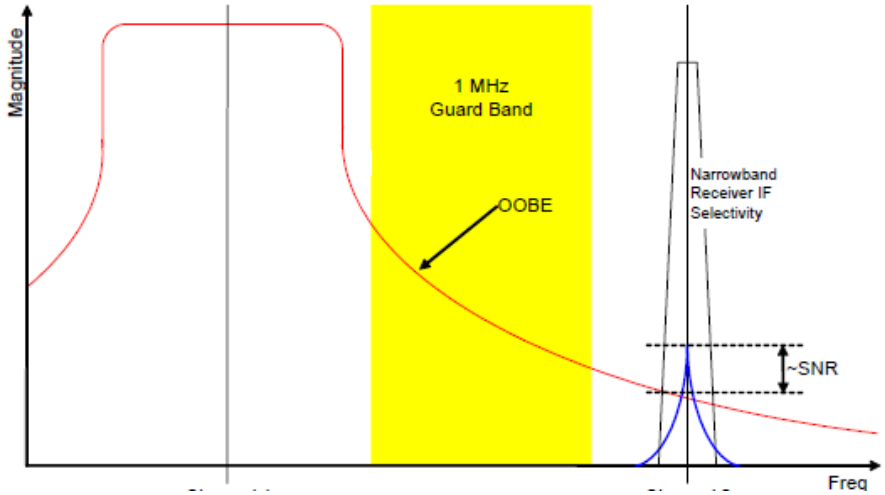

Figure A.2: OOBE Interference

The actual calculation of the width of the guardband and its impact on OOBE interference can be done using the unwanted emission limits specified in the LTE standards documents.[38] In general, the amount of protection afforded by the guardband increases or decreases with the width of the guardband.

Appendix B: Public Safety Narrowband (PS NB) Spectrum

The number of 700 MHz narrowband channels that would need to be repurposed needs to be compared to the total number of narrowband channels available to public safety.

Currently, 13.6 MHz of spectrum in the VHF (25 and 150 MHz) and UHF (450 MHz) bands and 9.5 MHz of spectrum in the 800 MHz band are available for public safety narrowband LMR operation (See Fig. B.1).[39]

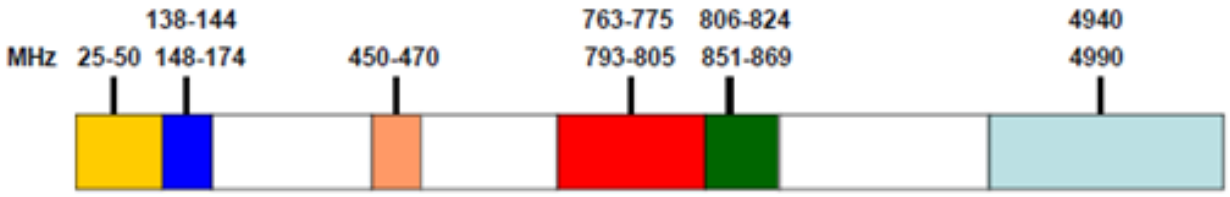

Figure B.1: Public Safety Narrow Band Spectrum for LMR Operations

[38] *See TS 361104-9c0, E-UTRAN: Base Station (BS) Radio Transmission and Reception,* www.3gpp.org
[39] *See* Chief Harlin R. McEwen, *Wireless Broadband is not an Alternative to LMR Mission Critical Voice Systems,* FCC PS Docket No. 06-229, filed Oct. 12, 2009.

UHF and VHF have advantages of higher coverage whereas 800 MHz operations allow higher capacity. The traditional channel bandwidth used was 25 KHz. The FCC narrowband mandate requires use of 12.5 KHz channels by EOY 2012.

The LMR channels in the 700 MHz PS NB are mandated to be 6.25 KHz channels, resulting in availability of additional 960 channels.

Preliminary Impact Analysis of Reduction of 700 MHz Public safety Narrow Band Spectrum

Based on current operations and the reduction of the channels to 12.5 KHz, the expected usage is 1848 channels prior to utilization of the 700 MHz narrow band channels. Assuming that the VHF, UHF, and 800 MHz spectrum are also provisioned with 6.25 KHz channels, this will increase the total number of narrow band channels available to public safety to 3696.

If the VHF, UHF, and 800 MHz spectrum continue to rely on 12.5 KHz channels, and the 6.25 KHz 700 MHz narrow band channels are added, this will result in 2808 channels.

The number of channels for the proposal is considered to be a combination of deployments of Options 1a and 1b, the estimated channels are 2485 assuming a 50% split between the two options.

Table B.1 summarizes the availability of NB channels

Table B.1: Number of Available Narrowband Channels

	Current: 12.5 KHz channels in VHF, UHF, and 800 MHz	Current modified to 6.25 KHz Channels	Current + 700 MHz band (6 MHz NB) Option 1a	Current (2 MHz NB)	Current + (Options 1a&1b)	Current (5.6 MHz NB)
# Channels	1848	3696	2808	2168	2485	2744

It may be noted that Option 1(a) does not affect narrow band operations.

Appendix C. Spectrum Value Calculation

Using the methodology in the previous cost study,[40] Table C.1 provides the estimates for the incremental economic value of the proposal using the template in Table 1 of that document. A 50%/50% split is assumed for the relative deployment of Options 1a and 1b. Table C.1 also provides estimates for the incremental economic value of the alternative options described in Appendix D.

Table C.1: Expenditure and Revenue Estimates

	Options 1a and 1b	Option 2	Options 3a and 3b	Option 4	Option 5
	50%/50% Deployment of 1a and 1b (15 MHz BB and 10 MHz BB)	2x10 MHz BB (2x2 MHz Guard) 2x6MHz NB	2x15 MHz BB (2x1 MHz Guard) 2x2MHz NB	2x(10+1.4) MHz BB (2x600kHz Guard) 2x6MHz NB	2x(10+1.4) MHz BB (2x1MHz Guard) 2x5.6MHz NB
(1) Capex for Build-out ($B)	11.5	11.5	11.5	11.5	11.5
(2) Interest Payment ($B)	0.2	0.3	0.1	0.2	0.2
(3) Total Build-out cost ($B)	11.7	11.8	11.6	11.7	11.7
(4) Operation and Admin Costs ($B)	13.9	13.9	13.9	13.9	13.9
(5) Revenue from Leasing Capacity ($B)	17.2	12.8	21.6	15.3	15.3
(6) Net Operating Income ($B)	3.3	-1.1	7.7	1.4	1.4
(7) Net Capex, Opex & Admin Costs	8.2	12.6	3.8	10.1	10.1
(8) Additional revenue wrt PSBB ($B)	**$4.4b**	**0**	**$8.8B**	**$2.5B**	**$2.5B**

[40] *See Kolodzy et al.*

Appendix D: Alternative Band Plan Options

This white paper recommends the band plan proposal described in section 3.0 (Option 1) because it allows FirstNet and key stakeholders to incorporate the Upper 700 MHz A-Block in a way that maximizes public safety flexibility. Under this recommended option, depending on specific public safety needs across different regions and over time, FirstNet and key stakeholders can choose to enhance interference protection (by increasing in the size of the guardband between the NPSBN and the public safety narrowband blocks) or add broadband capacity (by combining the additional A-Block spectrum with some repurposed narrowband spectrum to create an additional 2x5 MHz LTE channel).

In addition to this recommended option, we analyzed the following four additional options for incorporating the A-Block into the deployment of the NPSBN.

Option 2: 2x10 MHz Broadband (2x2 MHz guardband)

Band plan Description

This alternative option is the same as Option 1a described in section 3.0. It would increase the internal public safety guardband from 2x1 MHz to 2x2 MHz. (Figure D.1)

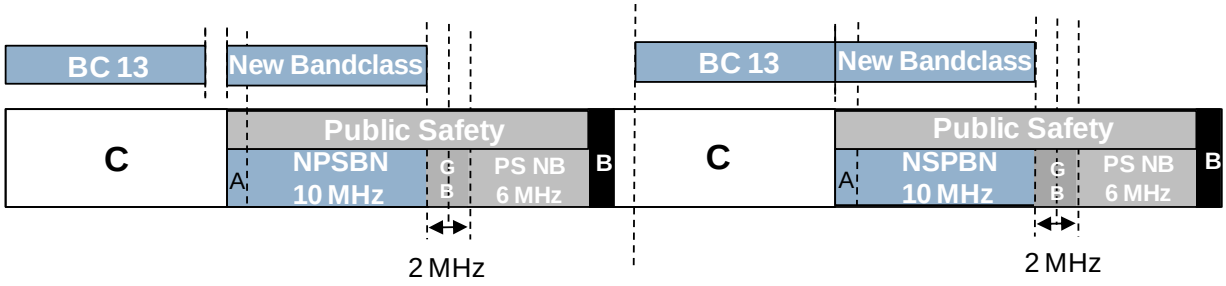

Figure D.1: 2x10 MHz Broadband plus 2x2 MHz Guardband

Value

Option 2 would have same benefits described above regarding the expansion of the guardband under Option 1a. Option 2, however, would not provide any additional broadband channels or capacity. The addition of the A-Block spectrum would solely be used to expand the guardband notwithstanding the potential for repurposing narrowband spectrum for broadband use and combining that spectrum with the A-Block spectrum to create additional LTE channels.

Impact

Shifting and expanding the public safety broadband spectrum would at minimum require redefining 3GPP band class 14, and modification of the RF portions of transceiver equipment and components already designed for public safety. Creation of a new 3GPP band class for the upper 700 MHz band would require additional 3GPP standards development.

Option 3: 2x15 MHz Broadband (2x2 MHz narrowband)

Band Plan Description

This option creates a new, significantly larger (by 50%), 2x15 MHz LTE broadband spectrum block for public safety by adding the A-Block to the NPSBN broadband spectrum block, while also reducing the public safety narrowband spectrum by 2x4 MHz. As shown in Figure D.2, there are two sub-options for deploying LTE in the newly created 2x15 MHz spectrum block. Option 3a, like Option 1b described above, maintains the planned 2x10MHz LTE carrier, and adds a separate 2x5 MHz carrier. Option 3b provides a single 2x15 MHz LTE carrier. The public safety broadband spectrum lower band edge is extended 1 MHz lower to include the A-Block, thus creating a contiguous block of spectrum with the upper C block in which LTE can be deployed. In this proposal, the internal public safety guardband is maintained at 2x1 MHz, but the number of duplex narrowband channels is reduced by two-thirds to 320, compared to the 960 channels in the current band plan. The new public safety broadband spectrum range is 757-772 MHz for the downlink and 787-802 MHz for the uplink.

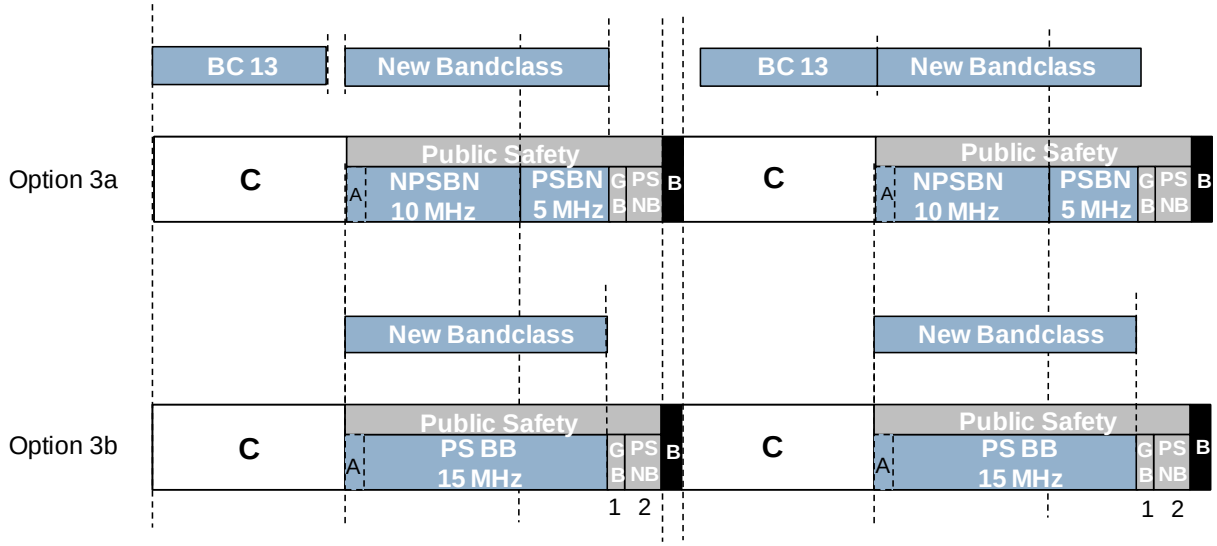

Figure D.2: 2x15 MHz Broadband plus 2x2 MHz Narrowband

Value

Both Options 3a and 3b maximize the amount of public safety spectrum for broadband applications. Both provide 50% more capacity than the existing 2x10 MHz spectrum. Option 3b also provides higher throughput potential for individual devices, particularly at the cell edge. For example, the number of simultaneous uplink video links would be significantly increased compared to 2x10 MHz.

Although these options would not provide the flexibility to expand the internal guardband in any region, they would enhance the NPSBN's capacity and significantly increase the number of broadband data users and services that can be supported. Option 3a would provide all of the

benefits of expanding broadband capacity as described under Option 1b. In addition, Option 3b provides a single high-capacity and high throughput LTE carrier.

Since it is recognized that not all mission critical voice communications may able to be accomplished by LTE, this option retains a total of 320 narrowband channel pairs for this type of operation, and for backward compatibility with legacy narrowband equipment.

Impact

As with Option 1b, Options 3a and 3b would require FCC approval to repurpose 640 narrowband channel pairs (out of a total of 960) for broadband use, and would require re-assignment of channels of any 700 MHz band narrowband equipment that is already deployed or planned for deployment. As with the other options, shifting and expanding the public safety broadband spectrum would at minimum require redefining 3GPP band class 14, and modification of the RF portions of transceiver equipment and components already designed for public safety. Creation of a new 3GPP band class for the upper 700 MHz band would require additional 3GPP standards development.

Option 4: 2x(10+1.4) MHz Broadband (2x600 kHz guardband)

Band Plan Description

This option creates an additional 1.4 MHz LTE channel by adding the A-Block to the existing public safety broadband spectrum while simultaneously reducing the internal public safety guardband from 2x1 MHz to 2x600 kHz. (Figure D.3). The public safety broadband spectrum band edge is shifted 1 MHz lower to include the A-Block in order to retain a 2x10 MHz LTE channel along with the newly created 2x1.4 MHz channel. The spectrum range for the new public safety broadband spectrum region is 757-768.4 MHz for the uplink and 787-798.4 MHz for the downlink. The number of public safety narrowband channel pairs is not affected.

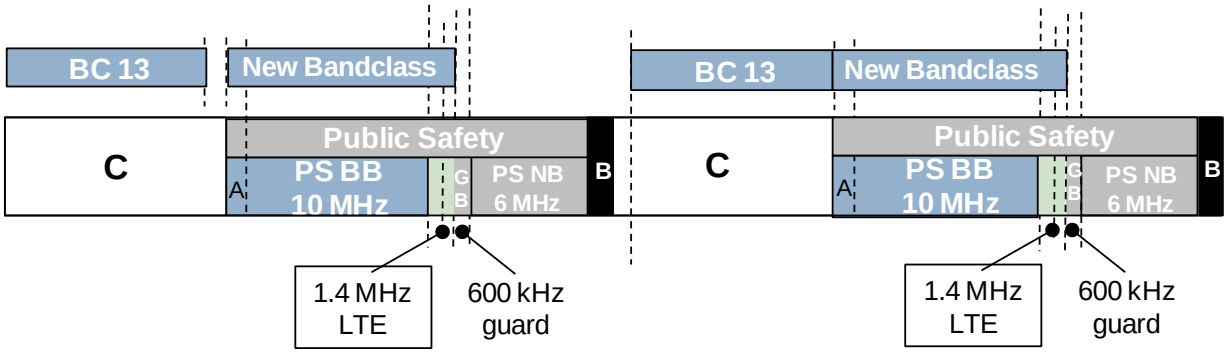

Figure D.3: 2x(10 + 1.4) MHz Broadband Spectrum plus 2x600 kHz Guardband

Value

The addition of a 1.4 MHz LTE channel to the public safety broadband spectrum holdings creates an approximate 12% capacity increase for the NPSBN. A primary application of this additional 1.4 MHz capacity could be the future phase-in and migration, from narrowband spectrum, of mission

critical voice services suitable for LTE operation. This would enable the creation of an integrated "voice plus broadband data" public safety user devices.

Alternately, the addition of a new 1.4 MHz LTE channel to public safety would allow for the option of local public safety agencies to share infrastructure with the NPSBN, and also deploy and operate on a dedicated local channel (although of lower capacity). The additional 1.4 MHz LTE channel could also be dedicated or reserved for emergency or priority use during disaster situations via the well-known LTE priority mechanisms, as described in detail in the 3GPP Release 8 version of LTE standards specifications, and discussed further with specific applicability to public safety in a recent FCC ex parte submission.[41]

The addition of the A-Block to the public safety broadband spectrum also creates a contiguous LTE spectrum block that facilitates the development of user devices that can operate seamlessly across the upper 700 MHz band, facilitating interoperability, and creating additional economies of scale opportunities for public safety user equipment.

Impact

The purpose of the 2x1 MHz internal public safety guardband is twofold: to protect traditional noise limited LMR systems from OOBE of adjacent broadband networks; and to protect broadband systems from OOBE of higher-powered LMR transmitters.[42] Reducing the guardband would result in a somewhat higher noise floor in adjacent LMR operating in geographic proximity. Appendix A provides the rationale for the guardband and the impact of reducing it from 2x1 MHz to 2x600 KHz. The impact is expected to be minimal. It is estimated to add a modest 2.4 db to the filtering requirements. Mitigation can also be done by narrowband/broadband frequency coordination and planning, and by using additional geographic separation between any extended 1.4 MHz LTE deployments and those narrowband channels immediately adjacent to the reduced guardband. Any coordination that would be required would be accomplished within the public safety community, that is, between FirstNet and the local public safety entities, since they have control over both the broadband and the narrowband operations.

Shifting and expanding the public safety broadband spectrum would require redefining 3GPP band class 14, and modification of the RF portions of transceiver equipment and components proposed for broadband public safety. This new 3GPP band class for public safety would of course require 3GPP standards development. The expanded band class 14 can be the foundation for a unified upper 700 band class for more effective interoperability and economies of scale if deemed appropriate at a future time.

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[41] *See T-Mobile USA, Inc, and Sprint Nextel Corporation Ex Parte Presentation, WT Docket No. 06-15; PS Docket No. 06-229; GN Docket No. 09-51, Public Safety Priority Access to Shared Commercial Networks, prepared by Roberson and Associates, LLC,* March 2, 2011.

[42] *See* FCC About Guardbands, *Second Report and Order (FCC 07-132) Service Rules for the 698-746, 747-762 and 777-792 MHz Bands*, available at http://wireless.fcc.gov/services/index.htm?job=about&id=700_guard

Option 5: 2x(10+1.4) MHz Broadband (2x5.6 MHz narrowband)

Band Plan Description

This option creates an additional 1.4 MHz LTE channel by adding the A-Block to the public safety broadband spectrum while also reducing the public safety narrowband spectrum by 2x400 kHz. (Figure D.4). The public safety broadband spectrum is shifted to accommodate a 2x1.4 MHz LTE channel adjacent to the 2x10 MHz public safety broadband block. In this option, the internal public safety guardband is maintained at 2x1 MHz, but the number of duplex narrowband channels is reduced by 64 to 896, compared to the 960 channels in the current band plan.

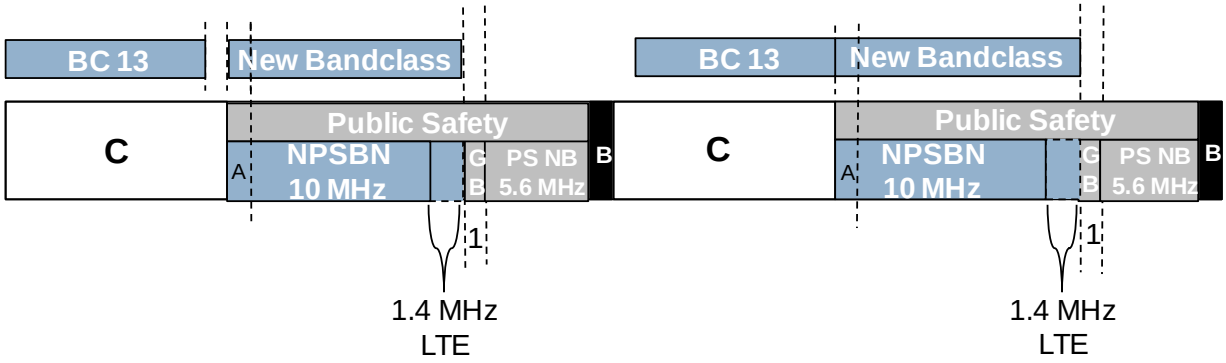

Figure D.4: 2x(10 + 1.4) MHz Broadband Spectrum plus 2x5.6 MHz Narrowband

Value

The value of an additional 1.4 MHz LTE channel for public safety broadband is the same as that described above with respect to Option 4: Increased capacity; potential for additional applications such as voice over LTE; integrated voice/data user devices; additional deployment options (local agencies and emergency capacity); opportunity for enhanced interoperability in the upper 700 MHz band; and public safety economies of scale with commercial devices.

Impact

Shifting and expansion of the public safety broadband spectrum would at require redefining 3GPP band class 14, and modification of the RF portions of transceiver equipment and components already proposed for public safety.

This option would require the FCC to allow 2x400 kHz of 700 MHz public safety narrowband spectrum to be used for broadband. It would also require re-assigning the frequencies of any narrowband equipment that may already be deployed or planned for deployment in the 64 narrowband channels immediately adjacent to the current internal public safety guardband. While not insignificant, 64 channels represent a small portion of the total 960 channels currently available in the 700 MHz public safety narrowband spectrum region, and an even smaller portion of the total number of narrowband channels available to public safety. (See Appendix B.) Trading off narrowband capacity for broadband capacity will be increasingly important in the future as the capability for mission critical voice is developed, and the use of broadband applications intensifies.

Comparing the Five Options

The following table compares the five band options described in this paper.

Table D-1 Band Plan Option Comparison

	Bandplan Option					
	1a	1b	2	3	4	5
Comparison Criteria	2 x 10 MHz NPSBB 2x2 MHz Gd. 2x6 MHz NB	2x5 MHz BB 2x1 MHz Gd. 2x2 MHz NB	2x10 MHz BB (2x2 MHz Guard) 2x6 MHz NB	3a) 2x15 MHz BB 3b) 2x10 + 2x5 BB (2x1 MHz Guard) 2x2 MHz NB	2x(10+1.4) MHz BB (2x600 kHz Guard) 2x6 MHz NB	2x(10+1.4) MHz BB (2x1 MHz Guard) 2x5.6 MHz NB
Impact on Commercial Operations	None		None	None	None	None
Broadband Capacity Increase	Potential Cell Edge Cap. Increase	50%	Potential Cell Edge Throughput	50%	~12%	~12%
Impact on Public Safety Broadband Equipment	Transceiver Bandshift		Transceiver Bandshift	Transceiver Bandshift	Transceiver Bandshift	Transceiver Bandshift
Public Safety Narrowband Channels	960	320	960 (same as current)	320	960 (same as current)	896
Public Safety Narrowband Impact	Better NB Protection	*Shift NB Voice to LTE. *Repack NB Voice.	Better NB Protection	Shift 67% of NB voice to LTE. Repack NB voice in public safety narrowband spectrum.	Requires Broadband Coordination	Shift 7% of NB voice to LTE
Broadband / Narrowband Coordination	More flexible	Same	Greater Flexibility	Same as current	Less Flexibility	Same as current
3GPP Standards Impact	New Bandclass		New Bandclass	New Bandclass	New Bandclass	New Bandclass
FCC Impact	Change 700 MHz Public Safety Bandplan		Change 700 MHz Public Safety	Change 700 MHz Public Safety Bandplan	Change 700 MHz Public Safety Bandplan	Change 700 MHz Public Safety Bandplan
Anticipates Future Public Safety Needs	* Provides for more Broadband Capacity * Anticipates Shift to Mission Critical Voice over LTE		No	* Provides more BB Capacity * Anticipates Shift to Mission Critical Voice	* Provides more BB Capacity * Anticipates Shift to Mission Critical Voice over LTE	* Provides more BB Capacity * Anticipates Shift to Mission Critical Voice over LTE
Deployment Approach	*Same approach as current NPSBN.	* Standard LTE *Same approach as current NPSBN. *Additional eNodeB transceiver & backhaul. * Flexible BB deployment * Future carrier aggregation	*Same approach as current NPSBN.	* Standard LTE *Same approach as current NPSBN. *Additional eNodeB transceiver & backhaul. * Flexible BB deployment (2x15MHz; 10+5 MHz) * Future carrier aggregation	* Standard LTE *Same approach as current NPSBN. *Additional eNodeB transceiver & backhaul. * Flexible BB deployment (local/national) * Future carrier aggregation	* Standard LTE *Same approach as current NPSBN. *Additional eNodeB transceiver & backhaul. * Flexible BB deployment (local/national) * Future carrier aggregation

Appendix E: Company Profile

Profile: Roberson and Associates, LLC

Roberson and Associates, LLC, is a technology and management consulting company serving government and commercial customers that provides services in the areas of RF spectrum management, RF measurements and analysis, strategy development, and technology management. The organization was founded in 2008 and is composed of a select group of individuals with corporate and academic backgrounds from Motorola, Bell Labs (AT&T, Telcordia, Lucent and Alcatel-Lucent), IBM, IITRI (now Alion), independent consulting firms, and Illinois Institute of Technology. Together the organization has over 300 years of the high technology management and technical leadership experience with a strong telecommunications focus.

Profiles: Roberson and Associates, LLC, Staff

Dennis A. Roberson, President and CEO, Roberson and Associates

Mr. Roberson is the Founder, President and CEO of Roberson and Associates, LLC. In parallel with this role he serves as Vice Provost and Research Professor in Computer Science at Illinois Institute of Technology where he has responsibility for IIT's corporate relationships including IIT's Career Management and Technology Transfer efforts. He also supports the implementation of IIT's Strategic Plan, the development of new research centers, and the successful initiation and growth of IIT related technology-based business ventures. He is an active researcher in the wireless networking arena and is a co- founder of IIT's Wireless Network and Communications Research Center (WiNCom). His specific research focus areas include dynamic spectrum access networks, spectrum occupancy measurement and spectrum management, and wireless interference and its mitigation and of which are important to the Roberson and Associates mission. He currently serves on the governing and / or advisory boards of several technology-based companies. Prior to IIT, he was EVP and CTO at Motorola and he had an extensive corporate career including major business and technology responsibilities at IBM, DEC (now part of HP), AT&T, and NCR. He is and has been involved with a wide variety of Technology, Cultural, Educational and Youth organizations currently including the FCC Technical Advisory Council and Open Internet Advisory Committee, the Commerce Spectrum Advisory Committee, and the National Advisory Board for the Boy Scouts of America and its Information Delivery Committee, and the Board of HCJB Global. He is a frequent speaker at universities, companies, technical workshops, and conferences around the globe. Mr. Roberson has BS degrees in Electrical Engineering and in Physics from Washington State University and a MSEE degree from Stanford..

Kenneth J. Zdunek, Ph.D., V.P. and Chief Technology Officer

Dr. Zdunek is Vice President and the Chief Technology Officer of Roberson and Associates. He has 35 years of experience in wireless communications and public safety systems. Concurrently he is a research faculty member in Electrical Engineering at the Illinois Institute of Technology, in Chicago, Illinois, where he conducts research in the area of dynamic spectrum access and efficient spectrum

utilization, and teaches a graduate course in wireless communication system design. He is a Fellow of the IEEE, recognized for his leadership in integrating voice and data in wireless networks. Prior to joining Roberson and Associates, he was VP of Networks Research at Motorola, a position he held for 9 years. Dr. Zdunek was awarded Motorola's patent of the year award in 2002 for a voice-data integration approach that is licensed and extensively used in GSM GPRS. He holds 17 other patents, included patents used in public safety trunked systems and cellular and trunked systems roaming. He directed the invention and validation of Nextel's iDEN™ voice-data air interface and IP based roaming approach, and was the principal architect of Motorola's SmartNet™ public safety trunking protocol suite. In the 1990's, he directed a Spectrum Utilization and Public Safety Spectrum Needs Projection submitted to the FCC in support of the 700 MHz spectrum allocation for Public Safety. He was awarded the BSEE and MSEE degrees from Northwestern University, and the Ph.D. EE degree from the Illinois Institute of Technology. He is a registered Professional Engineer in the State of Illinois.

Suresh R. Borkar, Ph.D. Senior Principal Investigator

Dr. Borkar is a Senior Principal Investigator at Roberson and Associates and a member of the faculty in the Electrical and Computer Engineering (ECE) department at the Illinois Institute of Technology (IIT), Chicago. Previously, he was with AT&T/Lucent Technologies/Alcatel-Lucent (ALU) for over 26 years responsible for various facets of product management, systems engineering, architecture, development, integration and testing, and customer management in Computer and Networking systems, Wireline Switching systems, Data systems, and Wireless systems. He was the Director for Customer Management for 3G mobility systems responsible for customer positioning, acceptance, and revenue realization. He was previously the Chief Technology Officer (CTO) and Managing Director, Lucent India Inc., responsible for all Lucent customer products and business activities in India. Dr. Borkar develops knowledge share and teaches advanced courses in Telecommunications and Computer Architecture for the Academia, IEEE, and the industry. He has been an organizer and moderator of conferences and panel discussions on WiMAX and VoIP/Next Generation Networks (NGNs). Dr. Borkar received his B. Tech. in Electrical Engineering from Indian Institute of Technology Delhi (India) and M.S. and Ph. D. in ECE from Illinois Institute of Technology, Chicago.